11:27:03 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 04/05/96

Active

Project #: E-20-X70 Cost share #: E-20-357 Rev #: 4
Center # : 10/24-6-R7904-0A0 Center shr #: 10/22-1-F7904-0A0 OCA file #:
Work type : RES
Contract#: DUE-9350862 Mod #: ADMIN REVISION Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: CIVIL ENGR Unit code: 02.010.116
Project director(s):
RIX G J CIVIL ENGR (404)894-2292

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 930901 to 970228 (performance) 970531 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	27,587.00
Funded	0.00	27,587.00
Cost sharing amount		27,587.00

Does subcontracting plan apply ?: N

Title: EQUIPMENT FOR NONDESTRUCTIVE EVALUATION OF INFRASTRUCTURE

PROJECT ADMINISTRATION DATA

OCA contact: Michelle A. Starmack 894-4820

Sponsor technical contact	Sponsor issuing office
NORMAN L FORTENBERRY	ANDREA R. KLINE
(202)357-7292	(202)357-9496
NATIONAL SCIENCE FOUNDATION	NATIONAL SCIENCE FOUNDATION
1800 G STREET, NW	1800 G STREET, NW
WASHINGTON, DC 20550	WASHINGTON, DC 20550

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO REVISE THE DELIVERABLE SCHEDULE.

5/12-1-97 (Awaiting U (2)

PROJECT CLOSEOUT - NOTICE

Closeout Notice Date 29-OCT-1997

Project Number E-20-X70 Doch Id 32277

Center Number 10/24-6-R7904-0A0

Project Director RIX, GLENN

Project Unit CIVIL ENGR

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Division Id 3393

Contract Number DUE-9350862 Contract Entity GTRC

Prime Contract Number

Title EQUIPMENT FOR NONDESTRUCTIVE EVALUATION OF INFRASTRUCTURE

Effective Completion Date 28-FEB-1997 (Performance) 31-MAY-1997 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory and Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REPORT.

Distribution Required:	
Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department	Y
Georgia Tech Research Corporation	Y
Project File	Y

E-20-X70

Georgia Tech

School of Civil & Environmental Engineering

Georgia Institute of Technology
Geotechnical Engineering Program
Atlanta, Georgia 30332-0355
USA
404•894•2282
404•894•2281 FAX
404•894•2292
INTERNET: glenn.rix@ce.gatech.edu

March 21, 1995

Dr. Norman L. Fortenberry
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

Re: Annual Progress Report for "Equipment for Nondestructive Evaluation of Infrastructure." (DUE-9350862)

Dear Dr. Fortenberry:

During the Spring Quarter of 1994, we taught the course "Nondestructive Testing of Infrastructure" (CE 4153) for the first time. The students' reaction to the course was very positive as indicated by the Course/Instructor Evaluation survey conducted near the end of the class. The results of the survey were included in a letter to you dated July 13, 1994.

This Spring Quarter we will again teach the course. At present there are 35 students (the maximum) pre-registered for the course. The course is now a critical component in a larger effort by the School of Civil and Environmental Engineering at Georgia Tech to develop an undergraduate curriculum focusing on Infrastructure Assessment, Rehabilitation, and Reconstruction. This effort is funded by an NSF Combined Research - Curriculum Development grant (EEC-9420522). This CRCD grant has provided resources to conduct extensive educational assessment of the effectiveness of the nondestructive evaluation course. The quantitative assessment will be performed during the upcoming Spring Quarter.

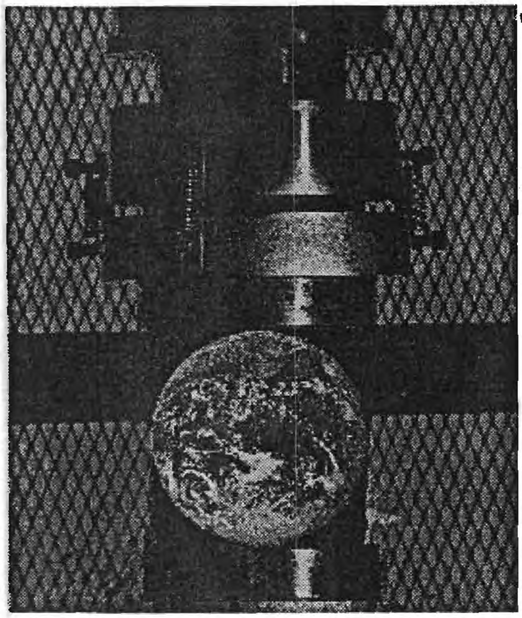
We have also taken steps during the past several months to assure that the course material is able to be disseminated to other civil engineering undergraduate programs who would like to incorporate a course in nondestructive evaluation in their curriculum. We are the most optimistic about electronic dissemination of the course material via the World Wide Web. Attachments to this progress report show a selection of the "Web pages" that are currently being developed. At the current time, these Web pages are unavailable to those outside of Georgia Tech because they are not yet complete. The course is also the subject of a poster presentation in the NSF/ILI session (No. 1626) at the upcoming American Society for Engineering Education Annual Conference and Exposition in Anaheim, California (June 25-28).

If you have any questions or comments about the development of the nondestructive evaluation course, we would enjoy hearing from you. Thank you again for providing the resources that have made it possible to teach this course.

Very truly yours,

Glenn J. Rix
Assistant Professor of Civil and
Environmental Engineering

Laurence J. Jacobs
Associate Professor of Civil and
Environmental Engineering



"Caution: Load Limit 60,000 ksi"

Georgia Institute of Technology

School of Civil & Environmental Engineering

CE 4153 – Non–Destructive Testing and Evaluation

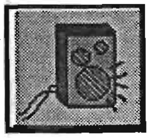
Instructors:

- Laurence J. Jacobs, Ph.D.
- Glenn J. Rix, Ph.D.

This course is an introduction to the use of nondestructive testing methods to evaluate the condition of civil engineering works. Special emphasis is placed upon the development of theoretical and experimental methods, and the connection between the two, to enable the student to gain a concrete understanding of the nature of the tests and the indications of the results.

As part of the growing curriculum on Infrastructure Assessment, Rehabilitation, and Reconstruction, the NDT class offers an enlightening perspective into many of the issues of real–world Civil Engineering. Commonly, an engineer is not called upon to design a new structure, but to verify the integrity of an existing one to see if redesign or rehabilitation is necessary.

Throughout the course of the quarter, students will learn the theoretical background necessary to apply the use of non–destructive techniques. Vibrations, wave propagation, signal processing and frequency analysis will all be touched upon so that the evaluation may be made of the character of the material and defect existence and location. Many hands–on experiments will be conducted and simulations performed to give the students a feel for the actual nature of the test. Several field trips will also be taken to see and use actual equipment in a real–world environment.



Audio Summary

Caution! This area is under construction.

- Course Outline
- Intro to Elastic Wave Propagation
- Intro to Signal Processing and Frequency Analysis
- Ultrasonic Evaluation of Structural Materials
- Acoustic Emission Techniques
- Intro to Vibrations and Structural Monitoring

Michael Bertz
School of Civil & Environmental Engineering, Georgia Institute of Technology
Atlanta, Georgia, 30332–0355, USA>
Internet: bertz@eiffel.ce.gatech.edu

Above picture is an unauthorized, edited, scanned image from Smithsonian Magazine.

Georgia Institute of Technology

School of Civil & Environmental Engineering

CE 4153 – Non–Destructive Testing and Evaluation

Elastic Wave Propagation in Solids

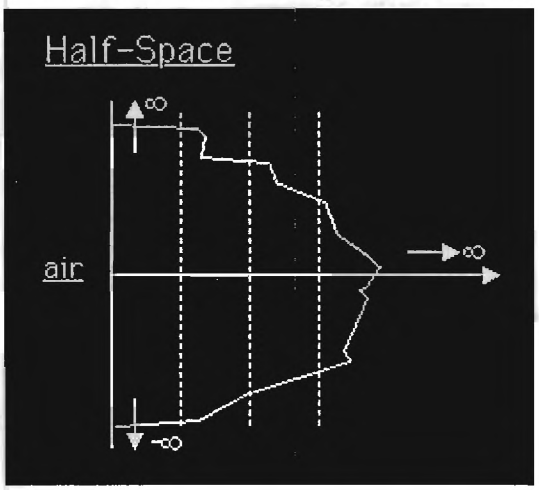
Elastic waves in solids share many of the behaviors intuitive to waves in the ocean or even radio waves in the electromagnetic spectrum. However, the visualization of waves through the use of strings and Slinkys (tm) may provide the most direct image of the relationship between the material and the wave.

The three principal types of waves are:

- Plane Waves
- Spherical Waves
- Surface Waves

Behavior of waves and theory of propagation

To better understand the mathematics that explain the theory of the behavior of elastic waves in solids, let's GEOMETRICALLY restrict ourselves for a moment to 1–dimensional solutions. Consider this 'half–space':



A half–space only has material to the RIGHT of the origin. Everything to the left is air. Yet the material is infinitely tall and long. The importance of this concept becomes clear when we examine the effects of an impact on the left edge. If we hit the left end with an infinitely big, flat surface, we would get plane waves that would propagate down the material – these are 1–dimensional longitudinal waves. They would propagate in the positive x–direction. The 1–D wave equation is:

1-D Wave Equation:

$$c^2 \frac{\partial^2 u}{\partial x^2} = \frac{\partial^2 u}{\partial t^2}$$

To solve for the stresses and displacements in this case, we'll consider a long, thin bar, and use a differential equations approach called D'Alembert's Solution.

Show me the derivation...

Back to CE 4153 Home page

Georgia Institute of Technology

School of Civil & Environmental Engineering

CE 4153 – Non–Destructive Testing and Evaluation

Plane Waves

Plane waves are defined as waves which, on a plane perpendicular to the direction of propagation, have constant solutions for the stresses, strains, and displacements. Therefore, these equations hold true:

Ux = Ux(x,t)

Uy = Uy(y,t)

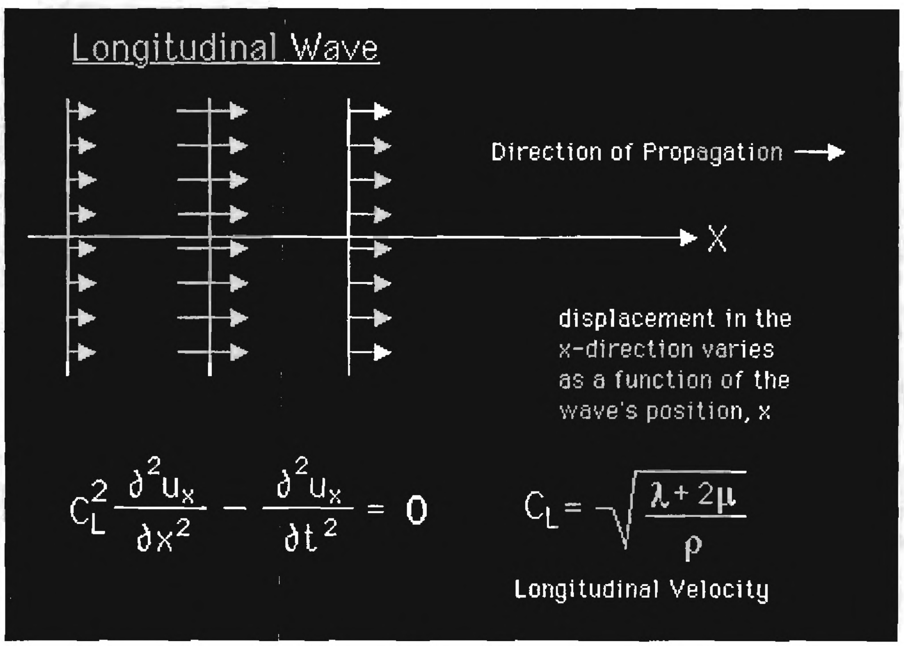
Uz = Uz(z,t)

We can commonly represent this type of wave as a planar wave front travelling along an axis, called the direction of propagation.

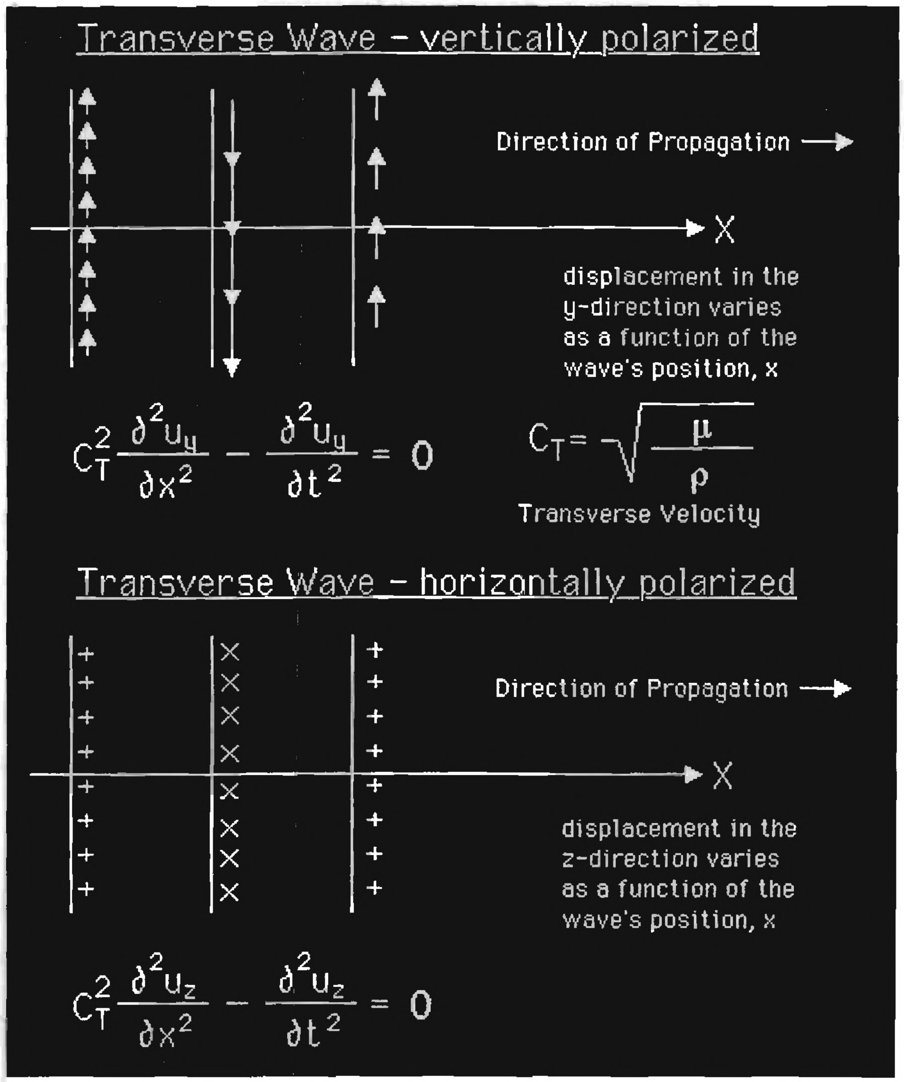
(GIF goes here)

There are two types of plane waves: longitudinal and transverse, or shear, waves. These can be explicitly defined by their mathematical equations:

Longitudinal Waves:



Transverse Waves:



The transverse type can be either vertically or horizontally polarized, with the direction of the stresses 'up' and 'down' or 'in' and 'out' of the screen. These are called SV and SH waves, respectively.

Back to Elastic Waves

Back to CE 4153 Home page

E-20-X70
2

Final Project Report

Thu Nov 20 10:35:16 1997

Part I - Project Identification Information

PI Name :Glenn Rix
Award No. :9350862
Institution :Georgia Tech Research Corporation - GA Institute of Technology
Award Completion Date:Feb 28 1997
Program Name :UNDERGRAD INSTRM & LAB IMPROVE
Division Name :DIVISION OF UNDERGRADUATE EDUCATION
Program Officer Name :Daniel B. Hodge
Project Title:
Equipment for Nondestructive Evaluation of Infrastructure

NSF Grant Conditions (Article 17, GC-1, and Article 9, FDP-11 require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days after the expiration of the award. Final Project Report for expired awards must be received
before new awards can be made (NSF Grants Policy Manual Section 677).

Below, attached to this form, provide a summary of the completed projects and technical information. Be sure to include your name and award number. See below for more instructions.

Part II - Summary of Completed Project (for public use)

The summary (about 200 words) must be self-contained and intelligible to a scientifically literate
reader. Without restating the project title, it should begin with a topic sentence stating the project's
major thesis. The summary should include, if pertinent to the project being described, the following
items:

. The primary objectives and scope of the project.
. The techniques or approaches used only to the degree necessary for comprehension.
. The findings and implications stated as concisely and informatively as possible.

Part III - Technical Information (for program management use)

List references to publications resulting from this award and briefly describe primary data, samples,
physical collections, inventions, software, etc, created or gathered in the course of the research and,
if appropriate, how they are being made available to the research community. Provide the NSF
Invention Disclosure number for any invention. (5 Page Maximum)

Part IV - Summary Data on Project Personnel (for program management use)

The data requested below are important for the development of a statistical profile on the personnel
supported by Federal grants. The information on this part is solicited in response to Public Law
99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be
safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a
single copy of this part with each final project report. However, submission of the requested
information is not mandatory and is not a precondition of future award(s). Check the "Decline to
Provide information" box below if you do not wish to provide the information.

Please enter the number of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants	
	Male	Fem	Male	Fem	Male	Fem	Male	Fem	Male	Fem
US Citizens\Permanent Residents:										
American Indian or Alaskan Native										
Asian										
Black, Not of Hispanic Origin										
Hispanic										

Pacific Islander
White, Not of
Hispanic Origin

Disabled

A.Total, U.S.Citizens

B.Total, P. Residents
C.Total, Other
Non-U.S. Citizens
Specify Country

Other Countries
D.Total, All Participants
(A + B + C)

Male Fem Male Fem Male Fem Male Fem Male Fem
Senior Post- Graduate Under- Other
Staff Doctorals Students Graduates Participants

Check this button if no personnel were supported by this award.
Decline to provide information:
Check this button if you do not wish to provide this information.
Check this button if you provide personnel information.

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and
scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any
accompanying publications or other documents, unless otherwise indicated, are the original work of
the signaturies or of individuals working under their supervision. I understand that willfully making a
false statement or concealing a material fact in this report or other communication submitted to NSF
is a criminal offense (U.S. Code. Title 18. Section 1001).

Name of Person Submitting:
Date: Nov.20, 1997

OMB No. 3145-0058

Send Comments to NSF.

Press to return to FastLane HomePage without processing selection. Data will NOT be saved

Other Participants
Category includes, for example, college and precollege teachers, conference and workshop
participants.
U.S. Citizens or Permanent Residents
Use the category that best describes the ethnic/racial status for all U.S. Citizens and Non-citizens
with Permanent Residency. (If more than one category applies, use the one category that most
closely reflects the person's recognition in the community.)
Disabled
A person having a physical or mental impairment that substantially limits one or more major life
activities; who has a record of such impairment; or who is regarded as having such impairment.
(Disabled individual also should be counted under the appropriate ethnic/racial group unless
they are classified as "Other Non-U.S. Citizens")
American Indian or Alaskan Native
A person having origins in any of the original peoples of North America and who maintains cultural
identification through tribal affiliation or community recognition.
Asian
A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian
subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.
Black, Not of Hispanic Origin
A person having origins in any of the black racial groups in Africa.
Hispanic
A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or

origin, regardless of race.
Pacific Islander
A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam,
American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of
Micronesia and Melanesia; or the Philippines.
White, Not of Hispanic Origin
A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.

FINAL REPORT:

Civil engineers play a central role in the nation's effort to renew our infrastructure. Most undergraduate civil engineering curricula focus on the analysis and design of new structures. In many instances, these skills are different than those required to assess the rehabilitation needs of existing structures. A new course, Nondestructive Evaluation of Infrastructure, has been developed and taught to students in Georgia Tech's School of Civil and Environmental Engineering to adequately prepare them to select and use nondestructive test methods. Funds provided by the project were used to purchase nondestructive test equipment for use in the class.

The course focuses on a variety of nondestructive test and evaluation methods including stress wave and electromagnetic techniques. These techniques are based on physical principles such as propagation delay (i.e., travel time), resonance, and dynamic stiffness. For each method, the lectures and laboratory sessions examine the principles and theories that form the basis of the method; test procedures and equipment; and interpretation and use of the test results. During the last week of class, student groups are given real and hypothetical problems and must prepare proposals for using nondestructive test methods to locate voids and flaws, determine the geometry of a structure, and measure physical properties of infrastructure components.

The course has been offered annually at Georgia Tech with an average enrollment of approximately 35 students.